[redacted]

[redacted]

NACA

RESEARCH MEMORANDUM

CLASSIFICATION CHANGED

TO Unclassified

BY AUTHORITY OF 2-4-52 Date

STABILITY AND CONTROL DATA OBTAINED FROM FOURTH AND FIFTH FLIGHTS OF THE NORTHROP X-4 AIRPLANE (A.F. No. 46-676)

By George M. Valentine

Langley Aeronautical Laboratory
Langley Air Force Base, Va.

CLASSIFICATION CHANGED

To [redacted]

By authority of [redacted]

NATIONAL ADVISORY COMMITTEE
FOR AERONAUTICS
WASHINGTON
August 4, 1949

[redacted]

NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

RESEARCH MEMORANDUM

STABILITY AND CONTROL DATA OBTAINED FROM FOURTH AND FIFTH FLIGHTS OF THE NORTHROP X-4 AIRPLANE (A.F. No. 46-676)

By George M. Valentine

SUMMARY

NACA instrumentation has been installed in the Northrop X-4 airplane to obtain stability and control data during the Northrop conducted acceptance tests. The results of the fourth and fifth flights of the Northrop X-4 number 1 airplane are presented in this paper. These data were obtained for a center-of-gravity position of approximately 19.5 percent of the mean aerodynamic chord.

The results of this flight showed that the directional stability as measured in steadily increasing sideslips was positive and high and that the effective dihedral was positive. The results also show the airplane to be longitudinally stable, stick fixed, with the center of gravity at 19.5 percent of the mean aerodynamic chord.

INTRODUCTION

As a part of the Air Force-Navy-NACA transonic-flight research program, the Northrop Company has constructed the X-4 airplane. This airplane is intended for performing research on a tailless configuration at high subsonic Mach numbers.

NACA recording instrumentation has been installed in the airplane to provide data on stability and control characteristics during the Northrop conducted acceptance tests. The present paper gives data obtained on the fourth and fifth flights made May 20, 1949 and May 25, 1949, respectively, with the center of gravity at approximately 19.5 percent of the mean aerodynamic chord. The speed range covered was 140 to 340 miles per hour indicated airspeed at approximately 15,000 feet pressure altitude.

SYMBOLS

V_i	indicated airspeed, miles per hour
β	sideslip angle, degrees
δ_e	elevon angle, degrees
δ_r	rudder angle, degrees
$\delta_{e_R} - \delta_{e_L}$	effective aileron angle, degrees
q	dynamic pressure, pounds per square foot
S	wing area, square feet
W	airplane weight, pounds
C_N	airplane normal-force coefficient $\left(\frac{Wn}{qS}\right)$
n	normal acceleration

Subscripts:

L, R	left and right elevons, respectively

AIRPLANE

The Northrop X-4 airplane is a semitailless research airplane having a vertical tail but no horizontal-tail surfaces. It is powered by two Westinghouse J-30-WE-7-9 engines and is designed for flight research in the high subsonic speed range. Photographs of the airplane are presented in figure 1 and a three-view drawing as figure 2. Table I lists the physical characteristics of the airplane.

TEST INSTRUMENTATION

Because of the small size of the X-4 airplane and the instrumentation requirements for the Northrop structure and engine-temperature measurements, it was possible to install only a minimum of stability and control instrumentation. Standard NACA internal instruments record altitude, airspeed, angle of sideslip, right and left elevon positions, and rudder position. In addition, the following quantities are telemetered to a ground station: normal acceleration, altitude, airspeed, right and left elevon positions, and rudder position. The telemeter was used during flight 4 but was not used during flight 5 because of interference with the Northrop temperature-measuring instruments. All of the records are correlated by a common timer.

The recording airspeed and altimeter are connected to the airspeed head on the vertical fin.

RESULTS AND DISCUSSION

In flight 4, the pilot made records of steady sideslips at several sideslip angles at constant speeds of 280 miles per hour and 175 miles per hour indicated airspeed. The pilot also made records of elevator position for trim at two speeds, 194 and 256 miles per hour indicated airspeed in the clean configuration, and at 140 miles per hour indicated airspeed in the landing configuration with flaps retracted and gear down. Data during a descent with dive brakes open and landing were also obtained.

In flight 5, records were taken of elevator position for trim at five speeds, 135, 152, 203, 275, and 340 miles per hour indicated airspeed, in the clean configuration, and elevator position for trim at three speeds, 151, 174, and 216 miles per hour indicated airspeed in the landing configuration with gear down and flaps retracted. Records were also taken of the lateral oscillations resulting from releasing the elevon from a steady sideslip with rudder "fixed" and releasing the rudder from a steady sideslip with rudder "free." Record of the landing was also taken.

A measure of the stick-fixed stability is shown in the upper portion of figure 3 and in figure 4 where the longitudinal control angle $\frac{\delta_{e_R} + \delta_{e_L}}{2}$ is plotted against indicated airspeed V_i and normal-force coefficient C_N. These data show that in the clean and in the gear-down flaps-retracted configurations the airplane is stable as shown by the increase in longitudinal control angle for trim with an increase in C_N. Acceleration of g was assumed to compute normal-force coefficient for flight 5. Data for determining values of C_N for these runs during flight 4 were not complete; hence, no data for flight 4 are included in figure 4. Included also in figure 3 is the lateral trim required for the speeds tested for gear-up and gear-down configurations.

Results of the measurements made in steady sideslips in flight 4 are given in figures 5 and 6 for which the rudder angle δ_r and effective aileron angle $\delta_{e_R} - \delta_{e_L}$ are plotted against sideslip angle angle β. These data show that the directional stability is positive and high as measured by the variations of rudder angle with sideslip angle, and the effective dihedral is positive as measured by the variations of effective aileron angle with sideslip angle. As expected, the effective dihedral increases with an increase in C_N. The variations of rudder angle with sideslip angle were 2.05° rudder angle per degree of sideslip angle at 175 miles per hour indicated airspeed and 1.90° rudder angle per degree of sideslip angle at 280 miles per hour indicated airspeed. The variations of effective aileron angle with sideslip angle were 0.66° effective aileron angle per degree of sideslip angle at 175 miles per hour indicated airspeed and 0.27° effective aileron angle per degree of sideslip angle at 280 miles per hour indicated airspeed.

Figures 7 and 8 are time histories of the lateral oscillations made by releasing the rudder from a steady sideslip of approximately 4° in flight 4. These data show that the oscillations were damped, but any exact measurement of damping is difficult because of elevon movement.

Figures 9 and 10 are time histories of lateral oscillations made by releasing the elevon from a steady sideslip and releasing the rudder from a steady sideslip, respectively, in flight 5. Data were taken after the disturbance had been made. In the elevon release with rudder fixed, the period of oscillation was 1.4 seconds per cycle, and the time required to damp to one-half maximum amplitude was 3.8 seconds. In the rudder release with rudder free, the period of oscillation was 1.5 seconds per cycle and the time required to damp to one-half amplitude was 3.1 seconds. These damping characteristics do not meet the specifications as set forth in the U. S. Air Force specifications no. 1815-B as being satisfactory.

Figure 11 is a time history of quantities measured during dive-brake operation. At time approximately 35 seconds with the airspeed stabilized at 270 miles per hour and with about 20 percent maximum power, the dive brakes were deflected 40 percent maximum deflection (pilot observation). Sinking speed of the order of 6000 feet per minute were recorded. Dive-brake deflection and flight conditions before time 35 seconds were not constant.

Time histories of the landings are given in figures 12 and 13 for flights 4 and 5, respectively. In flight 4, ground contact was made at 140 miles per hour indicated airspeed at a normal-force coefficient of about 0.67. The maximum up longitudinal control angle used was 14.6°. In flight 5, ground contact was made at 147 miles per hour indicated airspeed at a normal-force coefficient of 0.60. The maximum up longitudinal control angle used was 14.7°.

CONCLUSIONS

Data from flights 4 and 5 of the Northrop X-4 number 1 airplane with the center of gravity at approximately 19.5 percent of the mean aerodynamic chord show that:

1. The airplane is longitudinally stable, stick fixed, in the clean configuration and in the gear-down flaps-retracted configuration.

2. Directional stability is positive and high and effective dihedral is positive in the clean configuration for speeds of 175 miles per hour and 280 miles per hour indicated airspeed.

3. The damping of lateral oscillations does not meet the specifications as set forth in U. S. Air Force specifications no. 1815-B.

4. Sinking speeds for approximately 40 percent of the maximum dive-brake angle with 20 percent of maximum power at 270 miles per hour were approximately 6000 feet per minute.

5. The landings were made with flaps retracted at 140 miles per hour indicated airspeed corresponding to a normal-force coefficient of 0.67 in flight 4 and at 147 miles per hour indicated airspeed corresponding to a normal-force coefficient of 0.60 in flight 5.

Langley Aeronautical Laboratory
National Advisory Committee for Aeronautics
Langley Air Force Base, Va.

REFERENCE

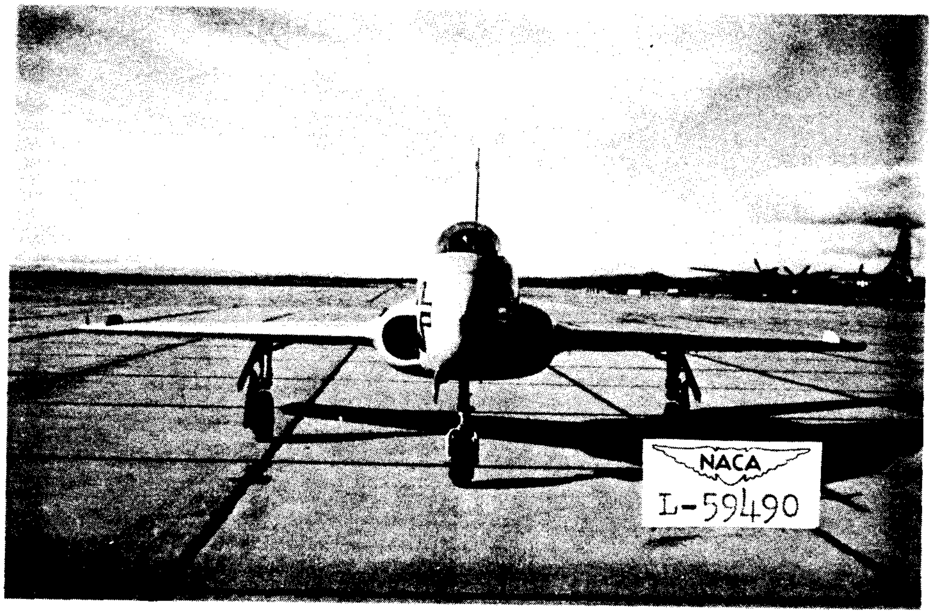
1. Drake, Hubert M.: Stability and Control Data Obtained from the First Flight of X-4 Airplane. NACA RM L9A31, 1949.

TABLE I

PHYSICAL CHARACTERISTICS OF NORTHROP X-4 AIRPLANE

Engine:	2 Westinghouse J-30-WE-7-9
Rating (each), lb static thrust at sea level	1600
Weight for acceptance tests, lb:	
Maximum 240 gal fuel	7696
Minimum (10 gal fuel trapped)	6316
Wing loading, lb/sq ft:	
Maximum	38.48
Minimum	31.58
Center-of-gravity travel (4th and 5th flights), percent MAC:	
Gear down	
Full load	20.00
Empty	17.85
Gear up	
Full load	19.70
Empty	17.45
Height, over-all, ft	14.83
Length, over-all, ft	23.25
Wing:	
Area, sq ft	200
Span, ft	26.83
Airfoil section	0010.64
Mean aerodynamic chord, ft	7.81
Aspect ratio	3.6
Root chord, ft	10.25
Tip chord, ft	4.67
Taper ratio	2.2:1
Sweepback (leading edge), deg	41.57
Dihedral (chord plane), deg	0
Wing flaps (split):	
Area, sq ft	16.7
Span, ft	8.92
Chord, percent wing chord	25
Travel, deg	30
Dive-brake dimensions as flaps:	
Travel, deg	±60
Elevons:	
Area (total), sq ft	17.20
Span (2 elevons), ft	15.45
Chord, percent wing chord	20
Movement, deg	
Up	35
Down	25
Operation	Hydraulic with electrical emergency
Vertical tail:	
Area, sq ft	16
Height, ft	5.96
Rudder:	
Area, sq ft	4.1
Span, ft	4.3
Travel, deg	30
Operation	Direct linkage

NACA



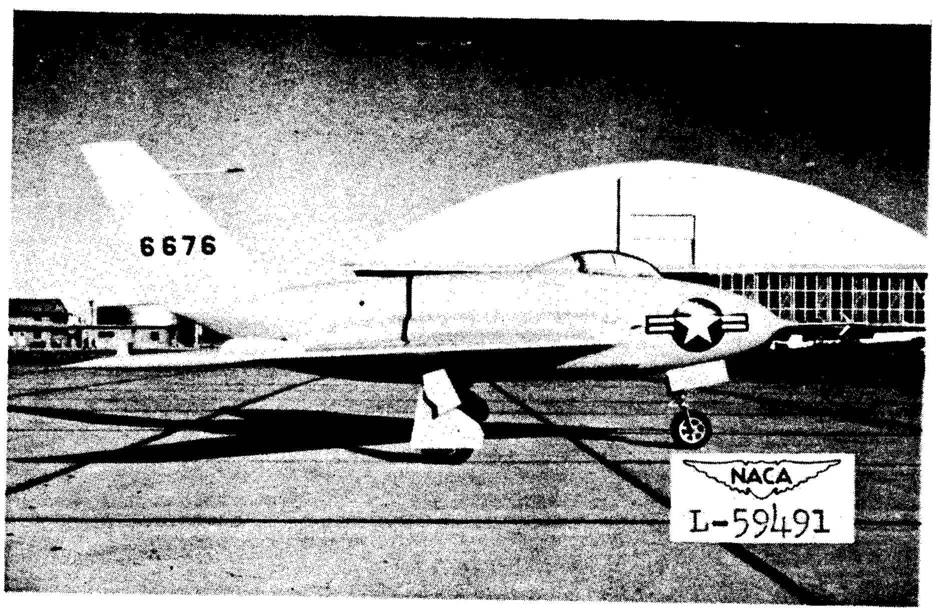
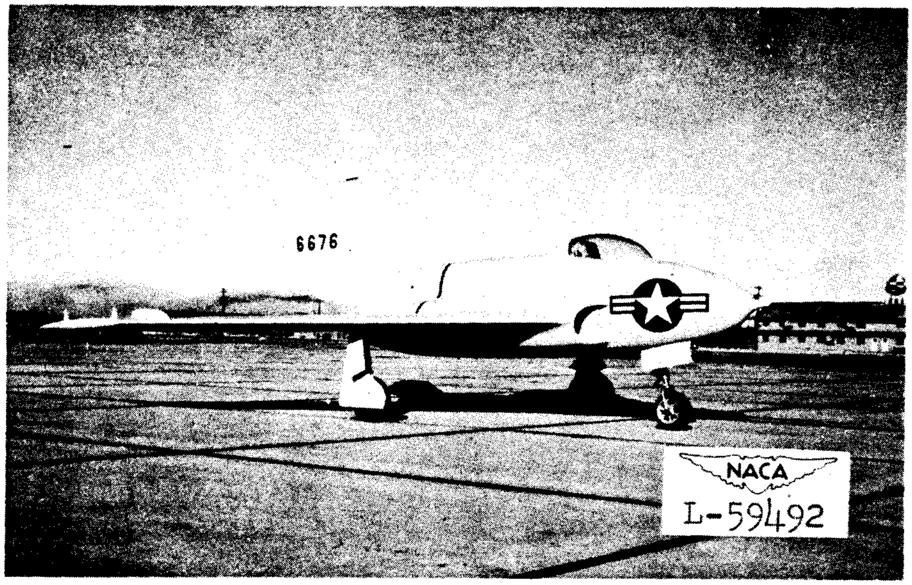


Figure 1.– Photographs of Northrop X-4 airplane.



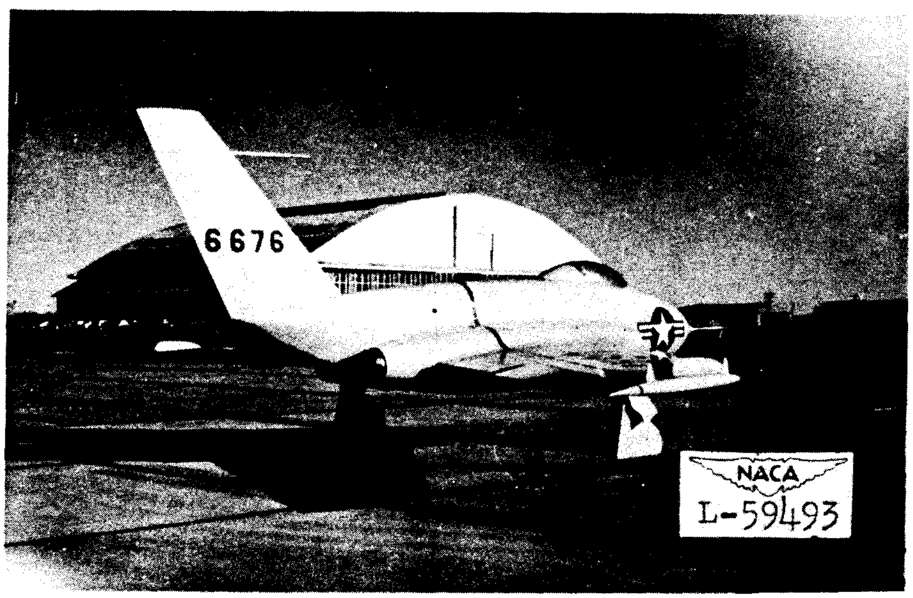


Figure 1.– Concluded.

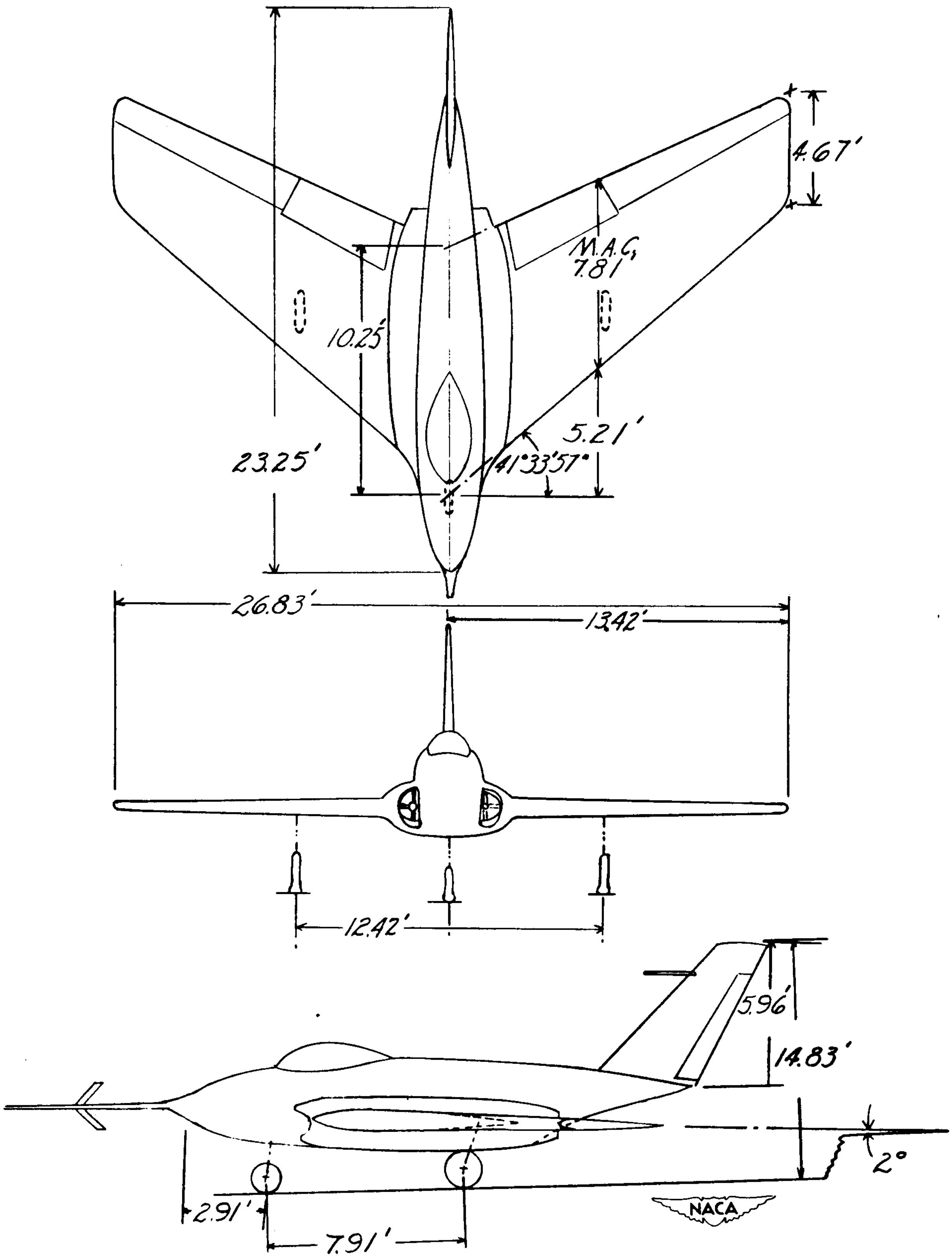


Figure 2.– Three-view drawing of Northrop X-4 airplane.

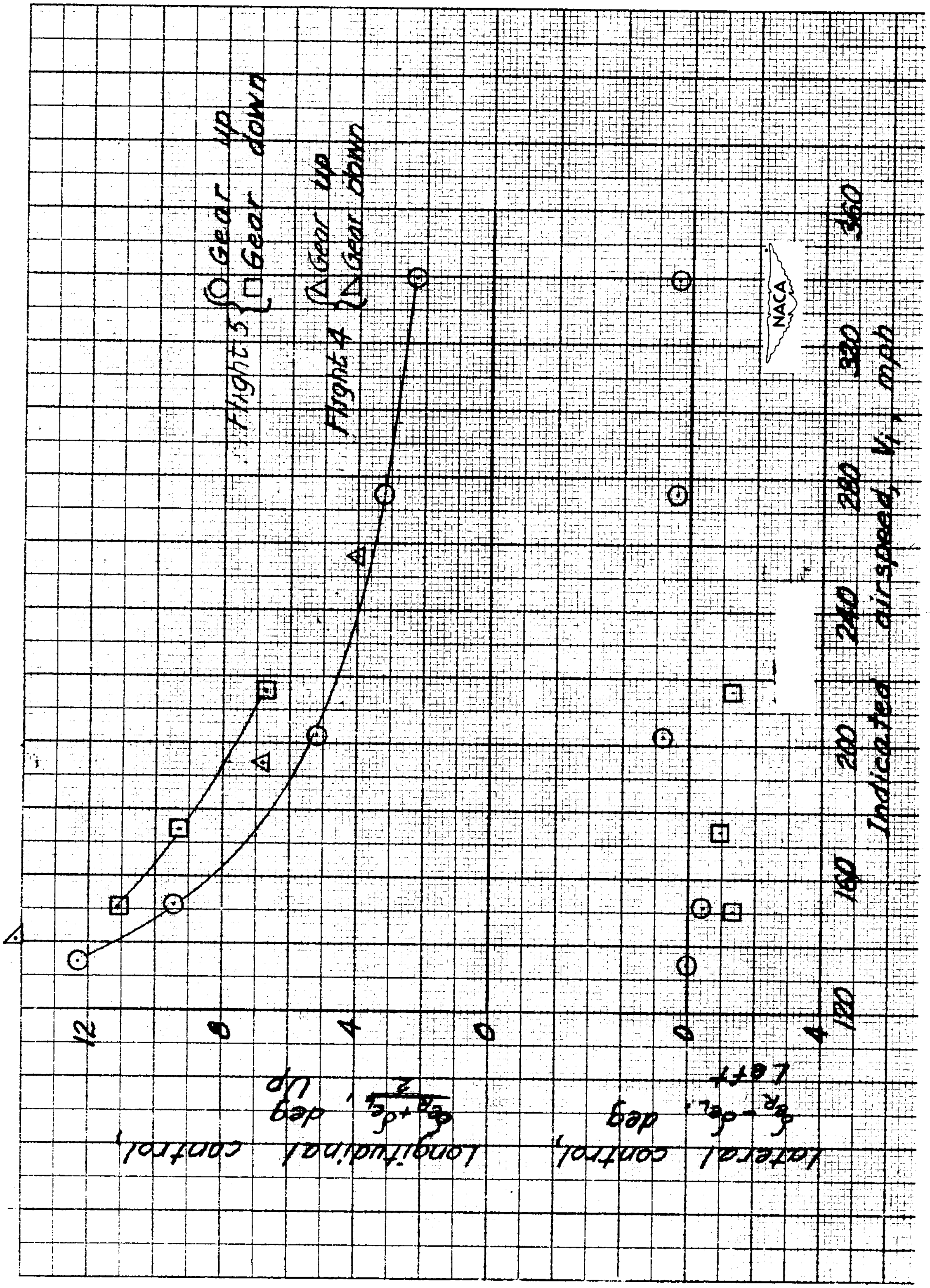


Figure 3.- Variation of elevon angle with airspeed for X-4 airplane.

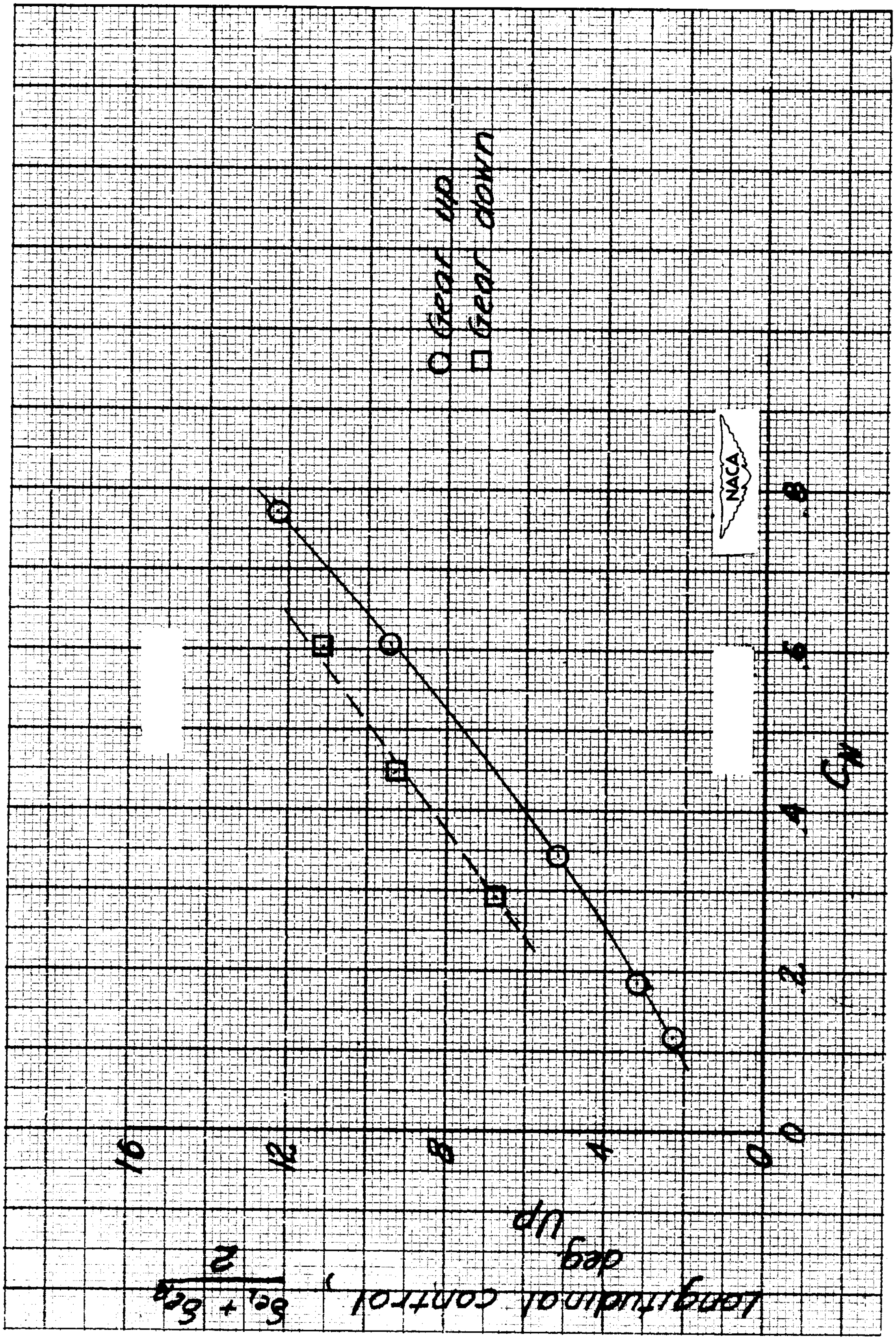


Figure 4.- Variation of longitudinal control with normal-force coefficient for X-4 airplane.

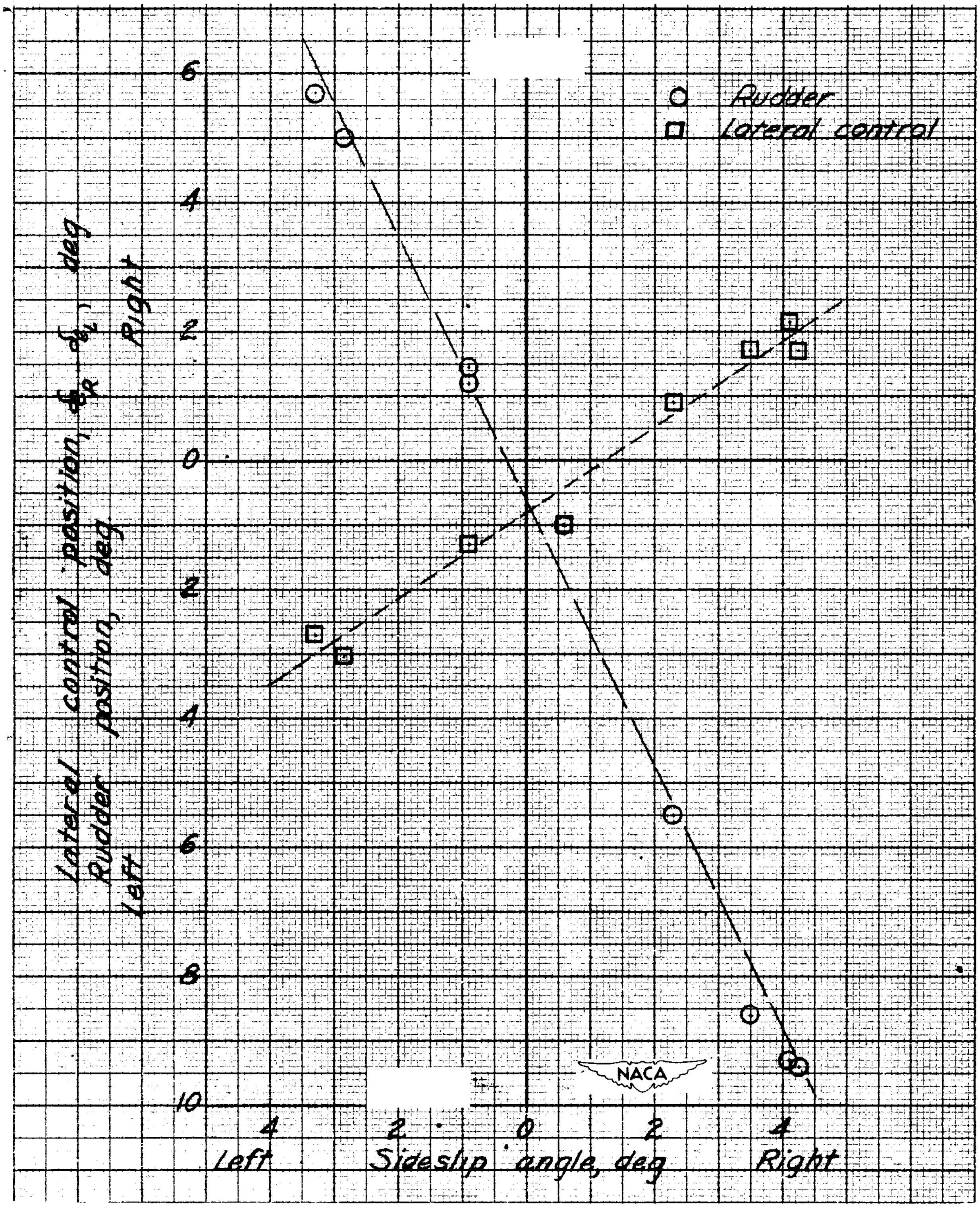


Figure 5.– Lateral–control position and rudder position at various side-slip angles at 175 miles per hour indicated airspeed, X-4 airplane.

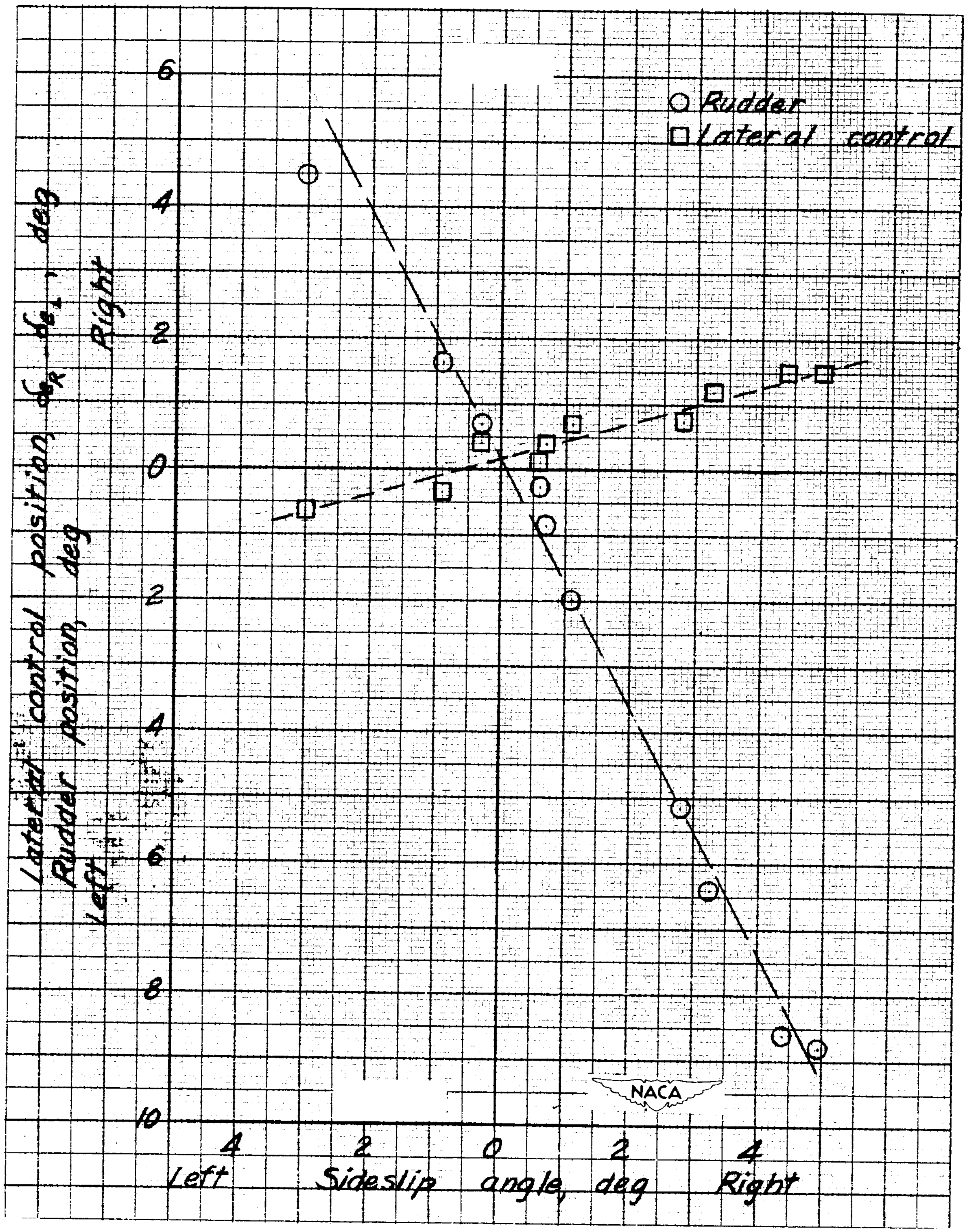


Figure 6.— Lateral-control position and rudder position at various sideslip angles at 280 miles per hour indicated airspeed, X-4 airplane.

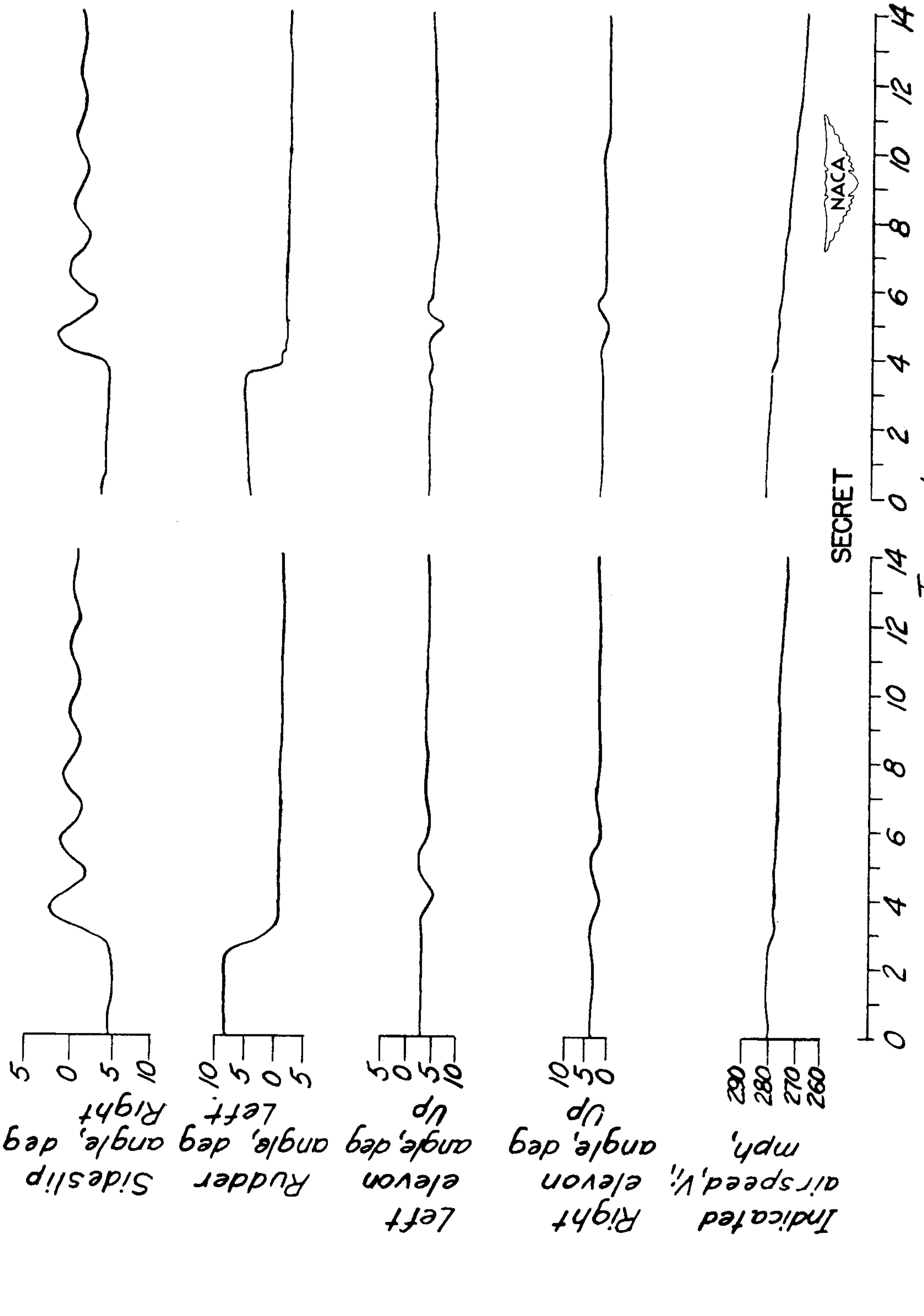


Figure 7.- Time history of rudder releases in steady sideslips for X-4 airplane.

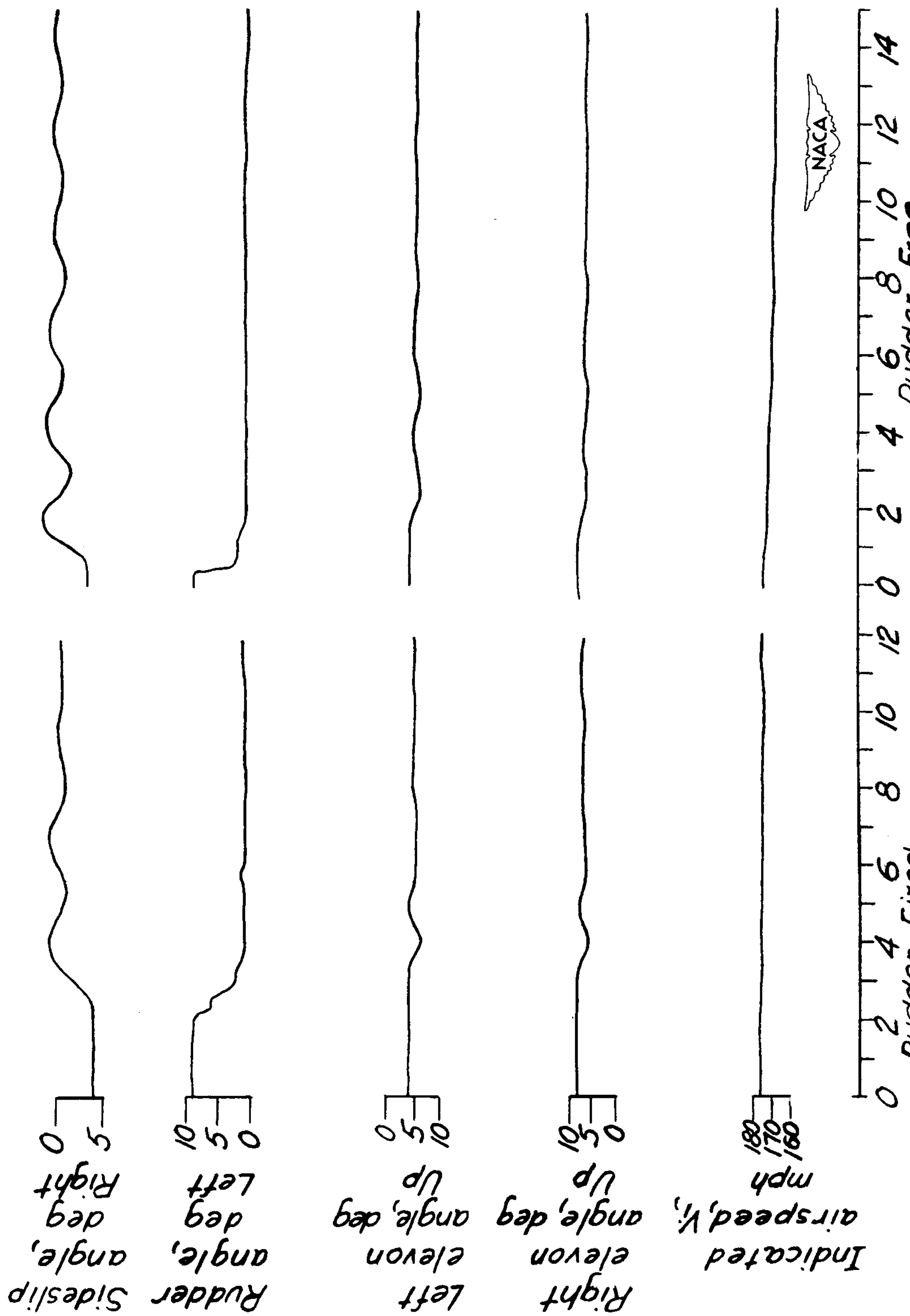


Figure 8.- Time history of rudder releases in steady sideslip for X-4 airplane.

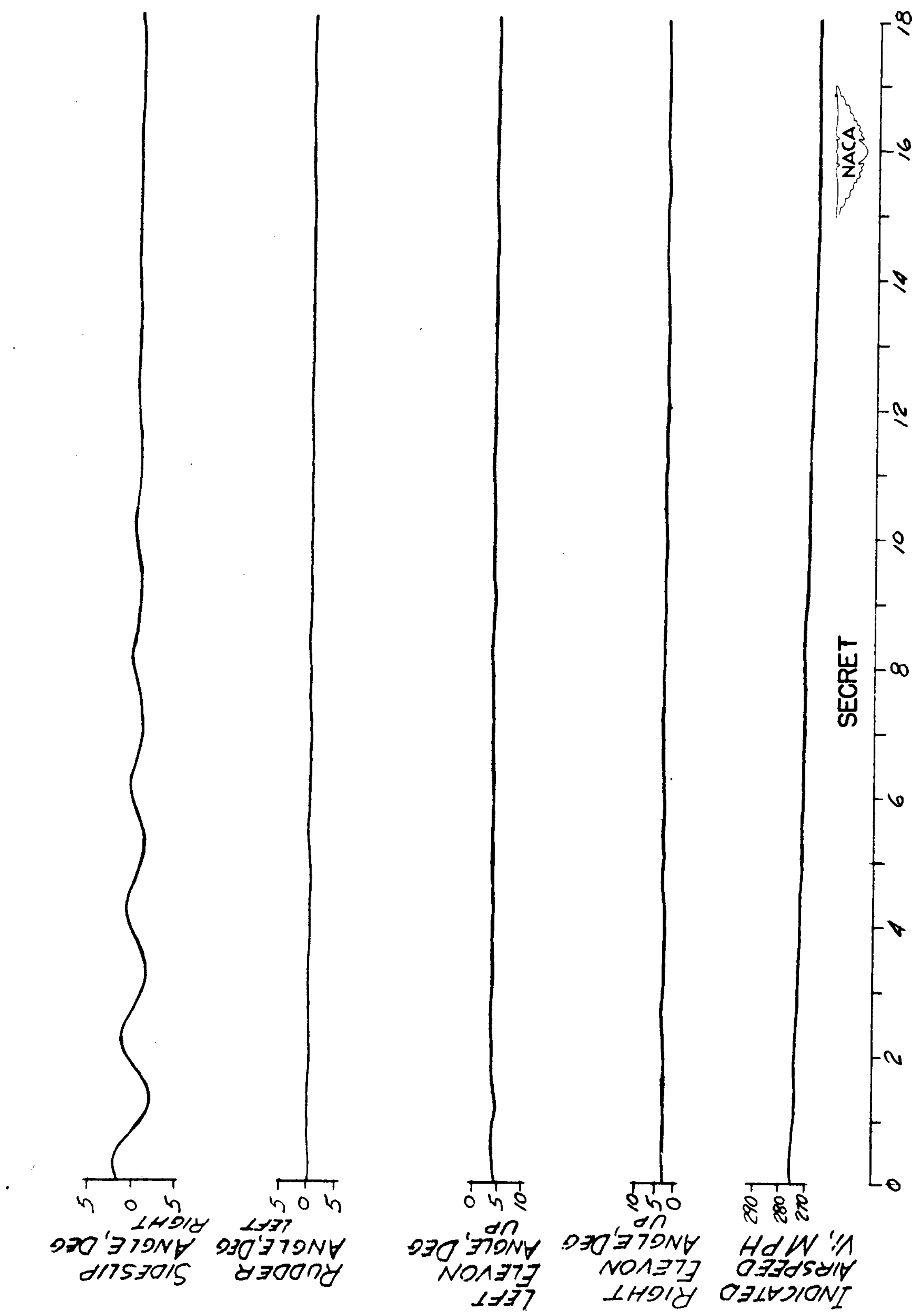


Figure 9.- Time history of elevon release in steady sideslip for X-4 airplane.

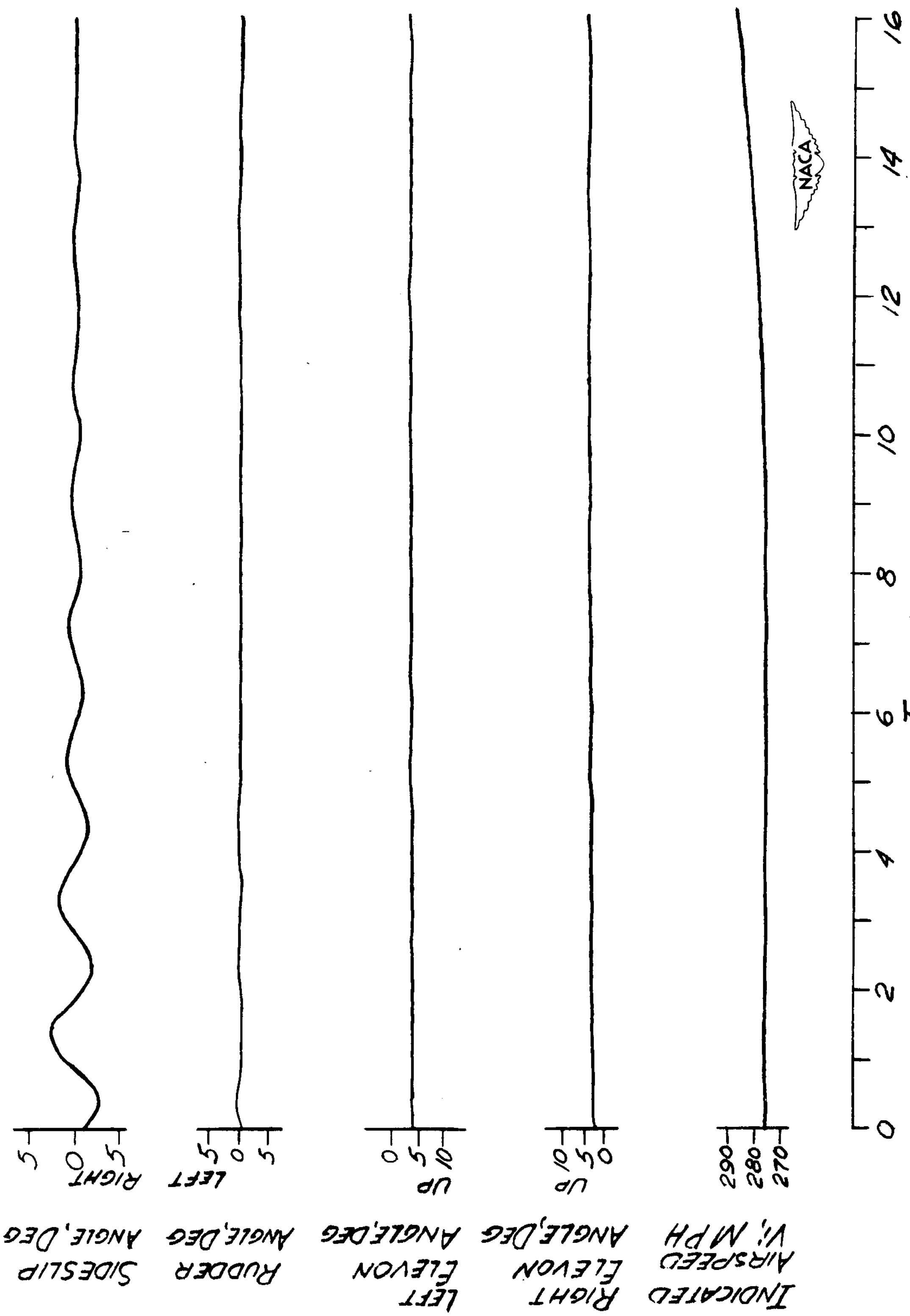


Figure 10.- Time history of rudder release in steady sideslip for X-4 airplane.

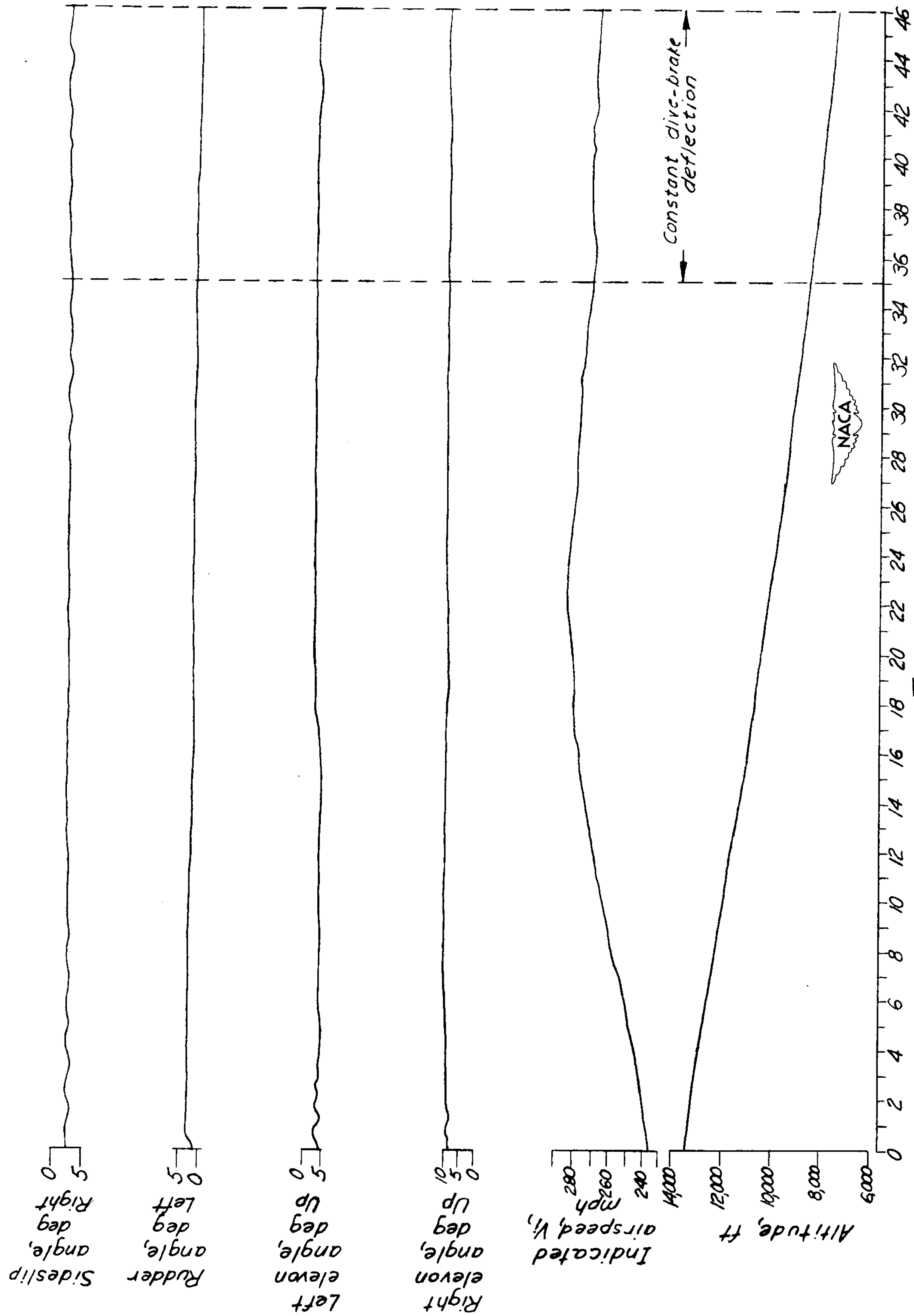


Figure 11.- Time history of descent with dive brakes open for X-4 airplane.

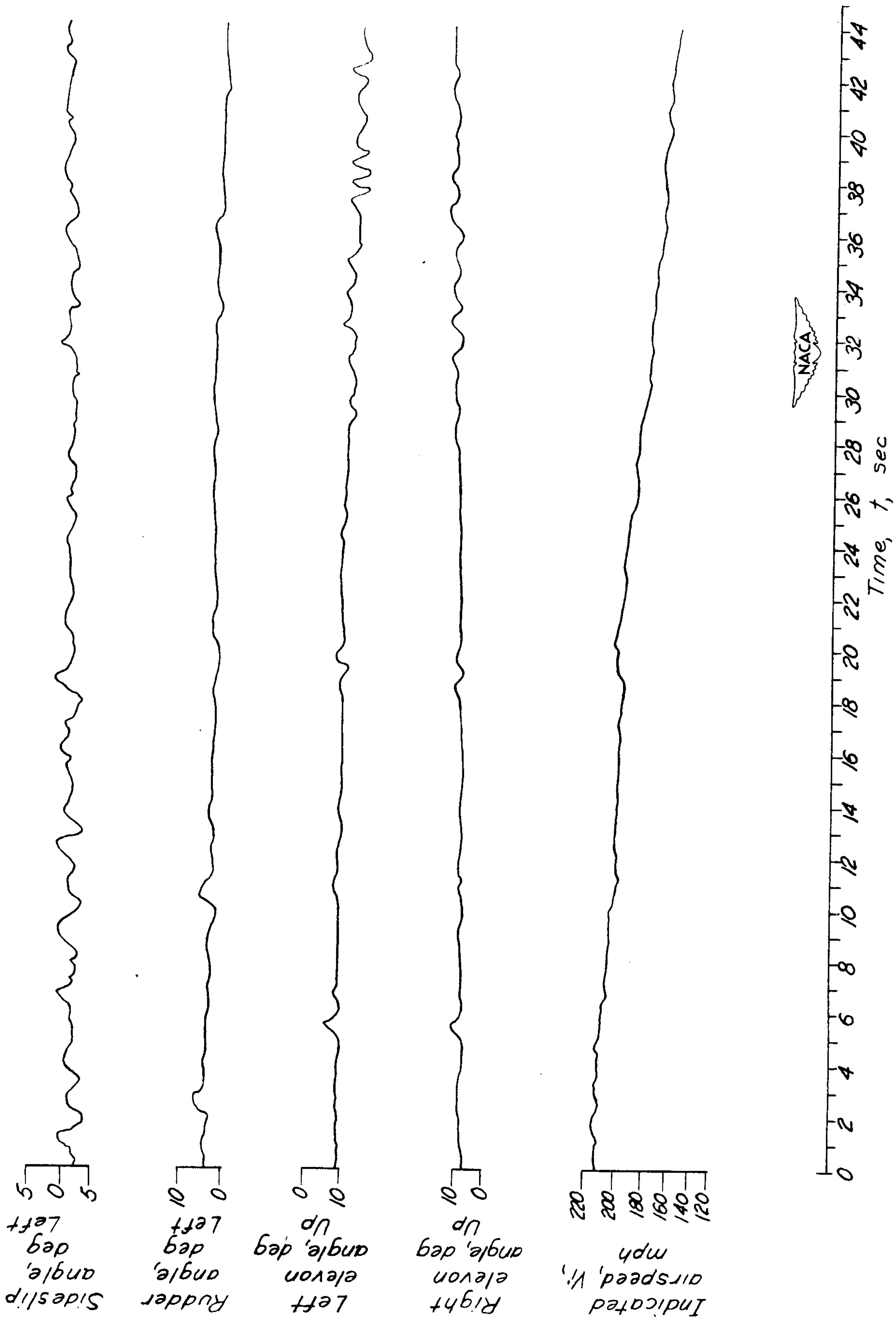


Figure 12.- Time history of landing for flight no. 4 for X-4 airplane.

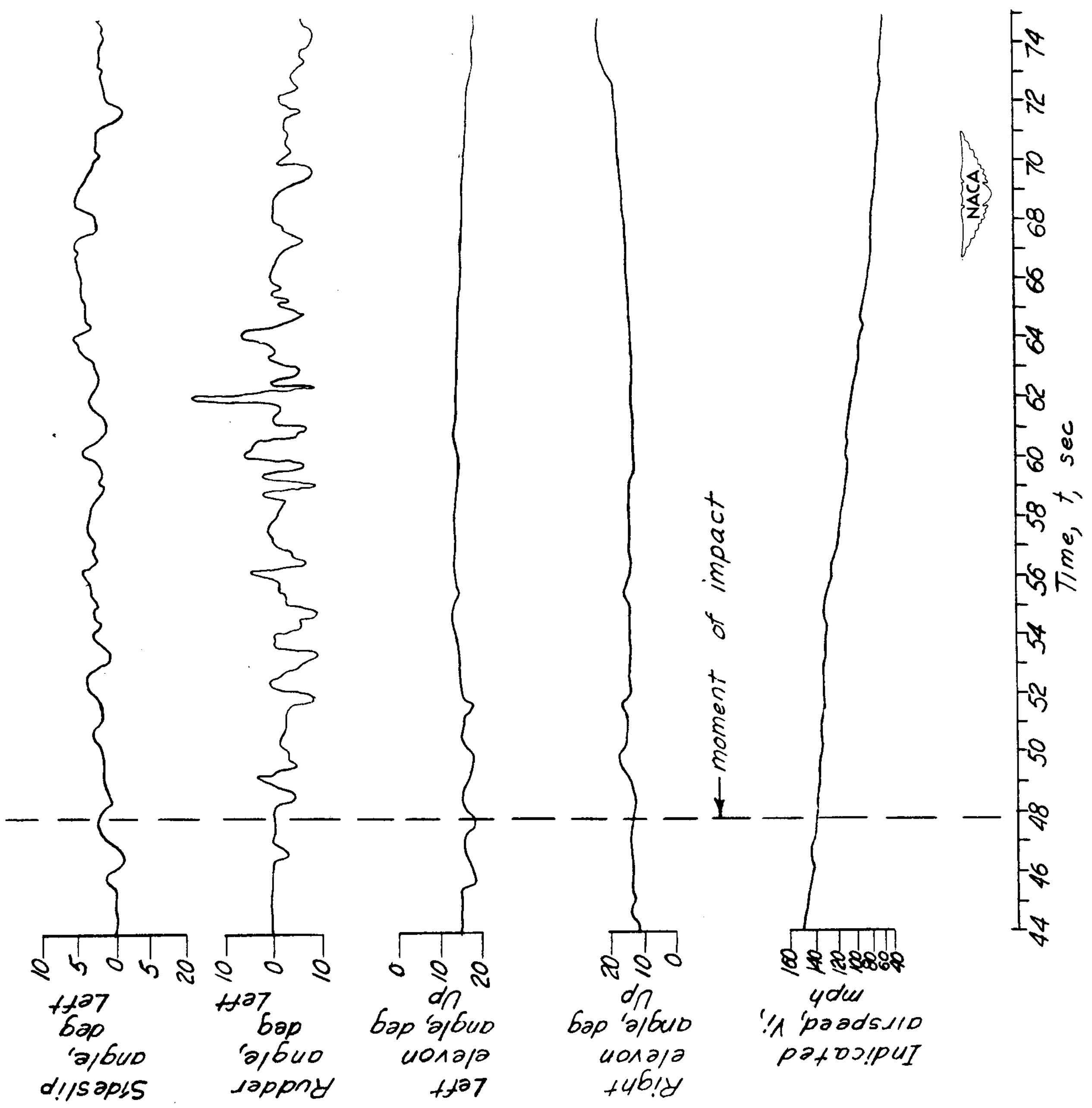


Figure 12.- Concluded.

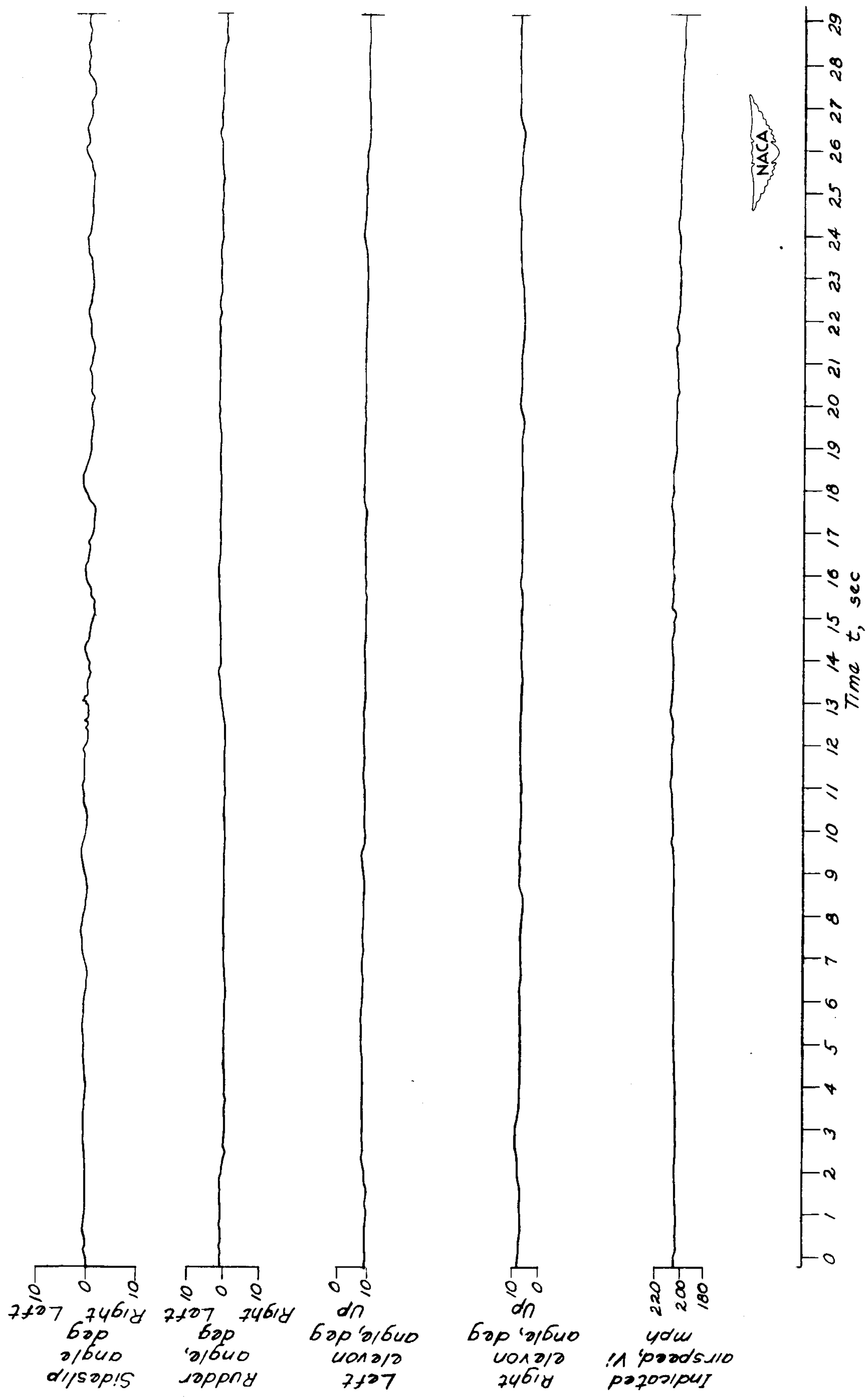


Figure 13.- Time history of landing for flight 5 for X-4 airplane.

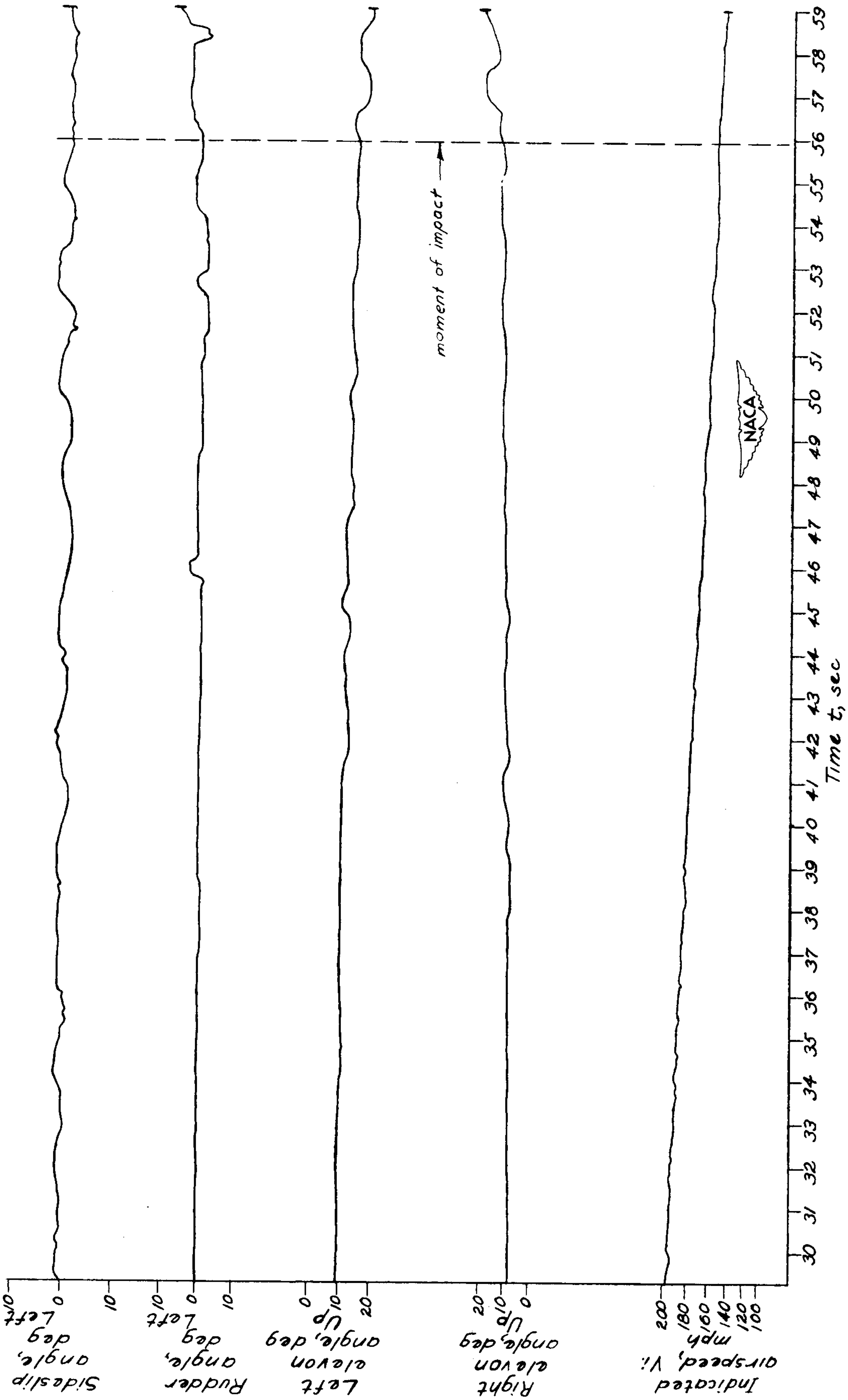


Figure 13.- Concluded.

NACA-Langley - 11-2-51 - 75